

SWEETPOTATO PRODUCTION GUIDES FOR HAWAI'I

Hector Valenzuela, Steven Fukuda, and Alton Arakaki

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INTRODUCTION

Sweetpotato (*Ipomoea batatas*), a member of the morning glory family, originated in South Mexico and Central America and is now the seventh most important food crop, world-wide. Sweetpotato, along with taro, was a major staple of the early Hawaiians. Commercial cultivation in the islands began in 1849. In 1919, sweetpotato was considered tenth in value among agricultural crops in Hawai'i when grown as an emergency crop during the war years. By 1948, the farm-gate value for sweetpotato was \$100,000. The sweetpotato is grown for its enlarged roots which can be boiled, baked, fried, or processed into chips. The stems and tips may be boiled or fried for use in soups and salads. Both roots and foliage can be grown as feed. The 1991 farm-gate value for sweetpotato in Hawai'i was about \$600,000. It is presently planted and harvested year-round throughout the state, with production acreage primarily in Moloka'i. Sweetpotato has a wide adaptability to Hawai'i's environments and has a high content of vitamins, beta carotene, and ascorbic acid. The young leaves, common in some oriental and Filipino dishes, have a 25 to 33 percent protein content on a dry weight basis.

CLIMATE

Short days promote fleshy root development and flowering, while long days promote top growth. The optimum soil temperature range for fleshy root development is 70 to 80°F (21 to 28°C). Optimum growing temperatures for top growth are >77°F (>25°C). Sweetpotato can be grown at altitudes of up to 2000 feet. It is considered to be drought tolerant. However, the plants are the most sensitive to deficits in irrigation during the first 40 days after planting. Sweetpotato yields in sandy loam soils with 25 percent moisture content will generally be similar or greater than yields in soils with 40, 60, and 80 percent moisture contents. Most cultivars are susceptible to waterlogging and to water tables <1.5 feet (<0.5 m). The sweetpotato tolerates a rainfall range of 20 to 50 inches (500 to 1300 mm) per growth cycle with optimum levels at 35 to 50 inches (900 to 1300 mm).

CULTIVARS

Two types of sweetpotato are grown in Hawai'i. The dry-fleshed with white to pale yellow or purple skin type is locally referred to as "sweetpotato." The second type, locally referred to as "yam," has moist, orange flesh and is used for baking. Hawai'i's population prefers the drier and firmer varieties of sweetpotato. Sweetpotato is, in fact, one word and should not be confused with the Irish or Peruvian potato (*Solanum tuberosum*), nor with the true "yam" (*Dioscorea* sp.). Dozens of clones are native to Hawai'i. Improved selections of many of these clones are still grown commercially or in home gardens throughout the state. Cultivar selection should be based on market demand, yields, and resistance to pests and diseases. Sweetpotato cultivars grown commercially on Kaua'i include lines 'UH 78-12' and 'UH 71-7'. Current cultivars recommended for local commercial production include:

Moist (baking) types:

1. 'Hoolehua Gold' – Reddish skin with orange flesh.
2. 'Kona B' – High-yielding cultivar. Light red to orangish skin with light orange flesh (Figure 1).
3. 'Iliua' – Orange flesh.



Figure 1. 'Kona B' is a moist-type, high-yielding sweetpotato. Proper root size and uniformity is required to meet Hawai'i grading standards for sweetpotato.

Dry (boiling, frying) types:

1. 'Waimanalo Red' – Early-maturing, high-yielding variety. Red skin with white flesh. This cultivar was introduced from Okinawa (Figure 2).
2. 'Hoolehua Red' – Red skin with white flesh.
3. 'Rapoza' – Whitish skin with purple flesh.
4. 'Onokeo' – Purple skin, white flesh, excellent quality.



Figure 2. 'Waimanalo Red' is a dry-type sweetpotato preferred in Hawai'i for boiling and frying. 'Waimanalo Red' is early maturing and high yielding.

Semi-dry type:

1. '71-5' – Light red skin with yellow-orange flesh.

Cultivars from the continental U.S. Standard commercial cultivars developed in the continental U.S. (moist type with orange flesh) perform well when grown in Hawai'i but take too long to mature (about 7 months) compared to local cultivars (about 5 months). Until recently, 'Jewel', developed by the North Carolina Experiment Station in 1970, was the standard cultivar representing 75 to 85 percent of sweetpotato production in the continental U.S., especially in areas with sandy loams. 'Jewel' is resistant to rootknot nematodes and fusarium wilt. It tolerates sweetpotato fleabeetles and internal cork. The Louisiana Experiment Station introduced 'Beauregard' in 1988. It is rapidly overtaking 'Jewel' in several production areas as the industry standard. 'Beauregard' is high yielding and matures a month earlier than 'Jewel' but is not nematode resistant and does not store as well as 'Jewel'. 'Satsuma' is a popular Asian variety in demand by Asian and Polynesian consumers in the continental U.S.

Sources of materials for local cultivars. Local grow-

ers; College of Tropical Agriculture and Human Resources, University of Hawai'i at Mānoa; County Extension Agents.

FERTILIZER RECOMMENDATIONS

Soil Type

Preferred soils are sandy loams that are leveled or slightly sloped, moderately fertile, and well drained. Poorly drained, heavy soils with clay result in irregularly sized and shaped fleshy roots. Soils high in organic matter may result in rough, cracked, jumbo-sized roots. Avoid soils contaminated with diseases, nematodes, or sweetpotato weevils. Three-year rotations are recommended to reduce damage from scurf and fusarium wilt. Optimum soil pH range is 5.5 to 6.8. Sweetpotatoes are sensitive to alkaline and saline soils. Cultivar selection varies depending on soil type where the crop will be grown.

Nutrient Uptake

Sweetpotato plants yielding 15,000 to 20,000 lbs/A accumulate an estimated 50 to 80 lbs nitrogen (N), 20 to 30 lbs phosphorus (P), 80 to 100 lbs potassium (K), 4 lbs magnesium (Mg), 5 lbs calcium (Ca), and 0.8 lb iron (Fe) on foliage and roots. Sweetpotato has a high requirement for potassium. Potassium uptake is dependent on the soil availability of magnesium.

Fertilizer Rates and Placement

Fertilizer applications should be made to complement the nutrient content already available in the soil. To assess the soil fertility status for sweetpotato production, conduct soil tests prior to planting. Soil samples should be taken and appropriate fertilizers added as recommended by University of Hawai'i soil scientists for that particular soil type. Applications which are made above levels required by plants may result in excessive foliage growth at the expense of root growth, nutrient leaching into aquifers, and in undesirable accumulation of salts in the soil root zone. Sweetpotato is a crop that requires nitrogen, phosphorus, and adequate potassium for optimum root growth. High nitrogen levels will cause excessive vine growth at the expense of root yields and may result in root cracking. Avoid planting on recently manured soils because it renders the tubers to become more susceptible to scurf infection. Estimated fertilizer recommendations for sweetpotato are 50 to 100 lbs/A nitrogen; 100 to 600 lbs/A of phosphorus (P₂O₅); and 100 to 150 lbs/A of potassium (K₂O). The following

fertilizer applications are recommended for Hawai'i based on soil test results:

1. Soil pH is below 5.0 and/or soil calcium content is below 1000 lbs/A:
Four to eight weeks before planting, apply 2000 lbs/A of agricultural lime on soils with adequate moisture. Incorporate to a depth of 6 inches with a disk or rototiller.
2. Moderate phosphorus and potassium soil levels:
650 lbs/A of 10-10-10 plus 130 lbs/A of 0-0-61 (murate of potash) fertilizer. Half is applied at planting and half is sidedressed 5 weeks later before rehilling.
3. Low phosphorus level soil (Consult with your local county agent to determine the phosphorus fixing rates typical in your area. The higher the soil phosphorus fixing rate, the higher the phosphorus fertilizer requirement):
1000 lbs/A of 0-47-0 pre-plant broadcasted in 12-inch bands in the plant rows and incorporated into the soil at a depth of 8 to 12 inches.
4. Sweetpotato has relatively low demand for nitrogen (40 to 50 lbs/A). Nitrogen applications of 100 lbs/A or more may be required in locations where soil nitrogen levels are low and high yields are expected.

Nutrient Tissue Analysis

Periodic nutrient analysis of foliage tissue provides an estimate of a crop's nutritional status and serves as a record of crop performance. The tissue analysis should be calibrated with soil fertility levels, according to soil samples taken before planting. For tissue analysis, collect a recently matured and healthy whole leaf. A representative tissue sample from a field will consist of 25 to 100 collected leaves free from insect or disease attack. Critical tissue nutrient levels have not been clearly established for sweetpotato. Nitrogen tissue contents up to 1.62 percent will increase the root to top growth ratio. Adequate soluble nutrient levels from sap analysis of sweetpotato petioles are 3500 ppm NO₃; 2000 ppm PO₄; and 5 percent K. Recommended optimum ranges from sweetpotato leaves and petioles are shown in Table 1.

CULTURE AND MANAGEMENT PRACTICES

Soil Preparation

To improve drainage, cuttings should be planted on 8- to 14-inch ridges. Ridge height will depend on soil texture. The soil should be turned 2 to 3 months prior to planting. Early plowing helps rot debris and reduces soil diseases and nematodes.

Table 1. Recommended tissue nutrient ranges for sweetpotato.

Nutrient	Range	Deficiency Level
N	3.2-4.2%	1.5-2.5%
P	0.2-0.6%	0.12%
K	2.9-4.3%	0.75%
Ca	0.75-0.95%	0.2%
Mg	0.40-0.80%	0.16%
S	0.22-0.30%	0.08%
Fe	100-250 ppm	30 ppm
Mn	40-100 ppm	2 ppm

Planting Distance

Plant 4 feet between rows and 10 to 12 inches between plants in the row.

Planting Material

Vine terminal cuttings or sprouts from tubers are used for sweetpotato propagation in Hawai'i. A spacing of 10 by 48 inches requires 13,068 cuttings per acre while a spacing of 12 by 48 inches requires 10,890 cuttings per acre. Cuttings should be about 12 inches long with about 8 nodes per foot (Figure 3). Roots develop from the buried nodes. Inspect all cuttings carefully. Discard those contaminated with insects, nematodes, or diseases.

Planting Method

Place cuttings of up to 2 days old in the open furrows by hand, and then cover with the use of a single disk

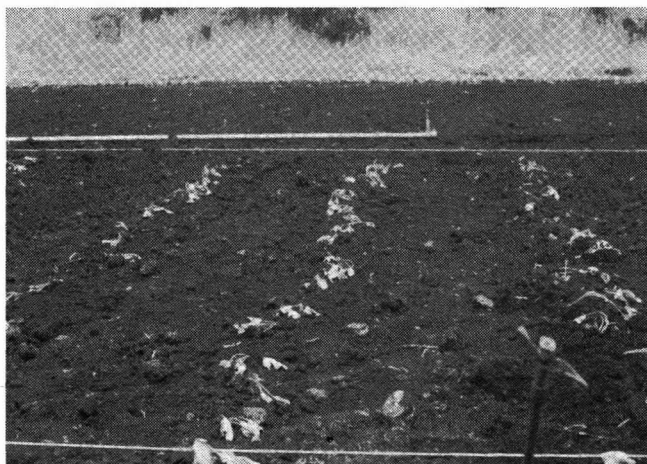


Figure 3. In Hawai'i, most sweetpotatoes are grown from 12-inch cuttings taken from the previous planting. Take cuttings only from fields which are free of insects and diseases.

behind a tractor. To improve uniformity of harvested roots, place cuttings horizontally if the crop will be irrigated. In rainfed or limited irrigated conditions, lay the cutting at a 45 degree angle. The angled planting results in larger roots close to the soil surface because the soil area is more likely to be moist. Bury cuttings at least 4 nodes deep.

Time of Planting

The best planting period in Hawai'i is March to May. Lowest yields occur when sweetpotato is planted from October to December. This is attributed to the shorter days and to the higher rainfall during that time of the year (Figure 4).

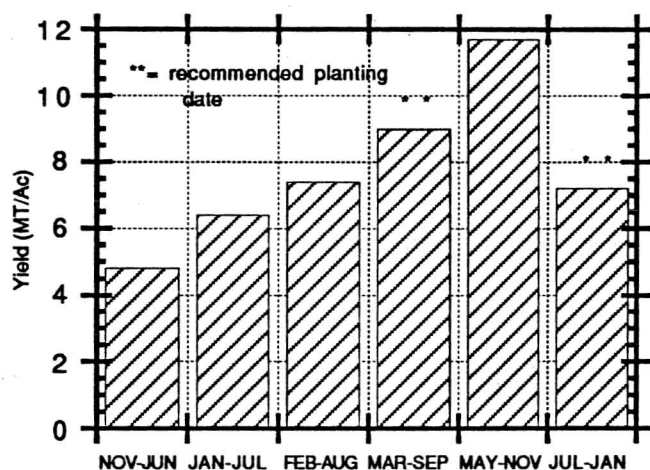


Figure 4. Mean yield of sweetpotato as affected by planting date in Poamoho (1953).

Hilling

Sweetpotatoes are hilled with a disk-hiller about 5 weeks after planting. A second fertilizer application is conducted just prior to hilling in fields which receive split fertilizer treatments. The hilling procedure consists of pulling soil from both sides and increasing ridge height and width by 1 to 3 inches. Hilling aids in weed control, root enlargement, and in reduced damage caused by the sweetpotato weevil.

Vine Turning

The main purpose of vine turning is to prevent roots from developing in the nodes of the expanding vines which come in contact with the soil. Small, irregular roots may develop if nodes from vines come in contact with the soil surface, draining carbohydrates from the

normal roots destined for market. Two to three vine turnings may be necessary several days after irrigation when vine growth is vigorous, especially on moist, fertile soils.

Mulches

The use of black plastic mulches in combination with drip irrigation increases both earliness and total marketable yields compared to bare-ground plants. Efficiency of water and fertilizer use may also be improved with the use of plastic mulches for sweetpotato production.

Irrigation

Sweetpotato yields in Hawai'i can be increased by 30 percent with timely irrigation. Generally, sweetpotato requires less water than most other vegetables. Irrigate moderately to improve stand establishment soon after planting. Maintain a constant water supply especially during the tuber formation stage at 7 to 9 weeks after planting. Irrigation is recommended when 40 to 50 percent of the field-capacity moisture has been depleted. Stop irrigation about a month before harvest.

Rotations

Sweetpotato should be raised in the same field only once every 3 or 4 years to reduce the incidence of insect and disease outbreaks. Sweetpotato residues may prevent nodulation in nitrogen fixing crops, which should be taken into account when designing a rotation schedule. Crops traditionally rotated with sweetpotato in Hawai'i include lettuce, spinach, beets, radish, kai choy, sweet corn, cowpea, peanut, bean, sorghum, alfalfa, and pigeon pea. Crops following sweetpotato in a rotation scheme should be carefully selected considering sweetpotato's allelopathic characteristics.

PESTS

Integrated Pest Management (IPM) consists of timely pesticide applications after all other economically viable alternative pest controls have been exhausted. Pest control techniques are recommended if lack of control results in monetary losses. Control practices are not recommended when the control activity would cost more than no control actions at all. The IPM strategy is based on (1) pest identification, (2) understanding of pest life cycles, (3) periodic pest scouting, and (4) development of a pest control strategy based on a systems approach which includes timely cultural, biological, and chemical controls.

To scout for sweetpotato pests, walk through the field at least on a weekly basis. Look for pests in the vines or for symptoms of poor plant growth. On a periodic basis, dig up roots and inspect them for signs of pest attack. Learn to identify the major pests of sweetpotato and to recognize the damage they cause to the plant.

Insects

Foliage and sap feeders attack sweetpotato but seldom reduce yields. These include: aphids, the sweetpotato whitefly, grasshoppers, red spider mites, and the sweetpotato leaf beetle. Insect pests which most often reduce marketable sweetpotato yields in Hawai'i include: the sweetpotato weevil, the gulf wireworm, the sweetpotato flea beetle, and the sweetpotato vineborer. Nematodes may also be a serious pest in non-resistant or non-tolerant cultivars. Emphasis of the IPM program is prophylactic to prevent pest attacks before they appear. Once a pest has been detected, losses are often inevitable.

Sweetpotato Weevil

The sweetpotato weevil, *Cylas formicarius* Elegantus, is the major insect pest of sweetpotato both in Hawai'i and around the world. The West Indian sweetpotato weevil, *Euscepes postfasciatus* (Fairmaire) is a destructive pest also found in Hawai'i. The adult *Cylas* beetle is about 1/2 inch long and resembles a large ant with a slender snout. The head and wing covers are blue-black and the middle body section and legs are light orange.

The adults may feed on foliage and roots. However most damage is caused by the larvae feeding on the fleshy roots. Hundreds of larvae may feed on one fleshy root under high pest pressure. Affected roots are unmarketable because of the feeding damage, presence of larvae, and the bitter flavor that develops on the roots in response to beetle feeding. Yield losses from weevil attack on sweetpotato are normally from 15 to 30 percent, but may be as high as 60 to 97 percent if pest populations go unchecked. Above-ground feeding by both larvae and adults does not normally have significant effect on marketable yields.

To control the weevil, rotate or fallow production fields, disc old sweetpotato fields to eliminate reservoir weevil populations in remaining plants, eliminate volunteer sweetpotato plants including weeds of the morning glory family, plant away from weevil-infested fields, hill the plants, and conduct timely insecticide applications. It is important to start with clean, uninfested cuttings, clean

fields, and to spray the base of the vines on infested fields every 3 to 4 weeks.

A commercial pheromone is available which attracts the adult males. This pheromone may be useful in a weevil control program for early detection of field infestations. In addition, the pheromone may be useful for mating disruption, as part of the overall weevil control program (Figure 5).

Fungi and parasitic nematodes have been identified which kill the sweetpotato weevil. However, further research is required to introduce these biological controls into commercially viable weevil control programs. In addition, selection of cultivars tolerant or resistant to the weevil is an important short- and long-term objective for control of the sweetpotato weevil. Thus far, resistance has not been detected in areas such as Hawai'i which experience extremely high weevil population pressures.

Gulf Wireworms

Conoderes amplicollis (Gyllenhal) is a yellow worm about 1 inch long which feeds on the fleshy sweetpotato roots. The larvae of the gulf wireworm makes small, irregular, ragged holes in the skin and burrows less than



Figure 5. Pheromone traps detect movement of sweetpotato weevil males into the field and may be helpful in control of this weevil through mating-disruption techniques.

1/4 inch into the fleshy roots. The feeding makes the roots unmarketable and allows the entry and spread of disease microorganisms. Feeding damage is normally greater under dry conditions. Wireworms may remain in the field for several years since the larvae may take over a year to mature into an adult beetle. Wireworms are controlled with timely insecticide applications.

Sweetpotato Fleabeetle

Chaetocnema confinis Crotch or fleabeetles are 1/16-inch-long, black beetles which jump when disturbed. Fleabeetle larvae feed on the roots leaving shallow tunnels below the periderm. The small tunnels enlarge as the roots grow and root cracks develop. The fleabeetles appear to move frequently from one feeding area to another. Volunteer weeds in the field margins may accentuate fleabeetle infestations in sweetpotato.

Sweetpotato Vine or Stem Borer

The vine borer, *Omphisa anastomasalis* (Guenee), is the second most important insect pest in sweetpotato, after the sweetpotato weevil. The larvae of vine borers feed inside the vines and crowns. Most yield losses in sweetpotato due to the vine borer are caused by damage to the vines and to the crown. Damage to the vines reduces movement of water, nutrients, and photosynthates up and down the vascular system. Heavy feeding results in reduced root growth of up to 50 percent.

The adult moths, which are most active at night, are white with a characteristic brownish yellow pattern in the wings. Eggs are laid singly below or above the leaf. Larvae begin to bore down the vines as soon as they hatch. The larval stages normally last 30 to 35 days. The larvae usually pupate in the vine for a period of about 2 weeks.

Insecticide sprays are ineffective because the borers are found inside the stems. Possible controls for the vine borer in sweetpotato include hilling (already practiced by farmers in Hawai'i), removal of alternate weedy *Ipomoea* hosts, planting tolerant cultivars, and timely insecticide applications to reduce elimination of natural enemy populations. Known parasitoids of the vine borer in Hawai'i include *Chelonus blackburni* Cameron, *Enytus chilonis* Cushman, and *Pristomerus hawaiiensis* Perkins.

Nematodes

Nematodes are tiny microscopic worms which live on plant roots and in the soil. Resistance to rootknot (*Meloidogyne* spp.) and, to a lesser extent, reniform (*Rotylenchulus reniformis*) nematodes has been developed

in sweetpotato cultivars grown in the continental U.S. Susceptible cultivars infested with nematodes wilt or appear stunted. Infested fleshy roots crack and show growth deformities. Roots of root-knot nematode infested plants also develop galls. Nematode susceptible cultivars should be grown in nematode-free soils. Rotate nematode infested soils with non-hosts such as sweet corn and other grasses. Soils may be tested for nematodes at the University of Hawai'i Diagnostic Center Laboratory. Nematicides should be applied if sensitive cultivars will be grown. Plow the field 2 to 3 months before planting to allow existing plant debris to rot prior to nematicide fumigant applications. To improve efficiency of nematicide application, read the label directions carefully and calibrate the applicator. In nematode prone areas, the use of resistant cultivars is one of the several management techniques used for nematode control in addition to rotation and fumigation.

Diseases

Diseases normally do not lower sweetpotato yields in Hawai'i because most plantings are started with disease-free tip cuttings. Leaf scab is a problem in some areas. To prevent the spread of diseases, handle the roots carefully during harvest to reduce bruising and maintain a clean sanitation program in the field, nursery bed, machine shop, and in the packing house. Other cultural practices such as proper rotations, field selection, spacings, fertilizer applications, and irrigation help to reduce disease infestation and spread in the field. In the continental U.S., commercial cultivars have been developed with resistance to *Fusarium* wilt and internal cork. Stem rot, black rot, soft rot, soil pox, scurf, and surface rot are all fungi that attack sweetpotato. Black rot, soft rot, and surface rot also attack fleshy roots during storage or during transit to their market destination.

Anthracnose

Anthracnose, caused by the fungus *Elsinoe batatas*, became a serious problem on sweetpotato plantings in Kaua'i in the late 1970s. Symptoms of the fungus are prominent on the younger parts of the vine as distorted leaves and petioles with rusty brown lesions. The vines take on a stunted and "scabby" appearance. Production is affected if the fungus infects the crop during the growing stage. Recommended controls include: (1) crop rotation (the fungus can survive in the refuse plant material after harvest), (2) the use of clean planting material (clean slips can be produced from roots treated

with a 10 to 20 percent chlorox solution for 20 minutes), and (3) the use of resistant or tolerant cultivars (the 'Waimanalo' cultivar appears to be tolerant to this disease).

Bacterial Stem and Root Rot

Erwinia chrysanthemi Burkholder, McFadden, and Dimock may appear in vines and roots in the field, in nursery bed roots, and during storage. Foliage symptoms include black, necrotic, water-soaked lesions. Eventually one or two branches of the plant will collapse resulting in wilting of terminal leaves. Lesions in the root develop more commonly in storage, with a characteristic black margin surrounding the lesions. The cultivar 'Beauregard' is very susceptible to root rot. This fungus penetrates sweetpotato principally through wounds created by handling or insect feeding. Controls include minimizing wounding of the roots, selection of propagating material from disease-free fields, and the use of cultivars with tolerance to the disease.

Black Rot

Symptoms caused by the the fungus *Ceratocystis fimbriata* (previously known as *Endoconidiophora fimbriata*) include leaf yellowing of young plants, underground sections of the stem show black areas, and circular, depressed, grayish blue lesions develop on the fleshy roots. Affected vines are stunted and the slightly shrunk, circular, black spot lesions in the root develop a bitter taste. Above- and below-ground lesions are localized and do not spread to the entire plant. Fungal spores reproduce rapidly and are easily spread by mites or the sweetpotato weevil during storage or transit to market. This results in severe postharvest losses. Black rot can penetrate the plant through wounds or injury caused by insects, nematodes, rodents, or farming equipment. This fungus persists in the soil for 1 to 2 years in affected roots left over after harvest or in the spore form. Recommended controls include the use of disease-free propagating material, fungicide treatment of seed roots, 3- or 4-year rotations, adequate curing of roots, and sanitation of any equipment or tools that may come in contact with the roots.

Internal Cork Virus

Internal cork is caused by the sweetpotato feathery mottle virus. Cross-sections of affected roots show dark brown, "cork-like" areas in the flesh. The virus also causes root necrosis. Infected roots usually appear normal on the outside. Foliage symptoms may range from

reddish purple spots to mild mottling and vein banding. Varieties vary in their response to internal cork virus. Sweetpotato cultivars developed in the continental U.S. have shown high tolerance to internal cork. To control, use cuttings from disease-free fields.

Scab

Characteristic symptoms caused by *Elsinoe batatas* are small, scabby areas and small, oval lesions, especially along the midrib and veins of leaves. The lesions eventually become corky resulting in shrinkage and leaf deformation. On the petioles, the damage spots may be a little larger and more sunken than on the leaves. The scab spots on both leaves and petioles may join together to a size of an inch or more. Yield losses from leaf scab can reach up to 60 percent. The tubers are not infected by this fungus. Scab can be spread by splashing rain and by utilizing infected cuttings for planting. Controls include disking the crop soon after harvest, 1-year rotations, planting of disease-free cuttings, and avoiding overhead irrigation in fields affected by leaf scab.

Soft Rot

The fungus *Rhizopus nigricans* (*R. stolonifer*), commonly called bread mold, is an important postharvest disease of sweetpotato. Affected roots develop a gray, fuzzy mold, turn soft, and later turn dry and hard. The fungus enters the roots through wounds. Recommended preventative measures include careful postharvest handling of the roots to prevent wounds, curing to heal any wounds, and disinfection of the packing shed and equipment. Spores are carried by wind and insects, especially flies. No cultivar resistant to soft rot has been identified.

Stem Rot or Fusarium Wilt

This fungus, *Fusarium oxysporum* Schlecht. f. sp. *batatas* (Wollenw) Snyd. & Hans., can be a serious pest in sweetpotato. Varieties resistant to stem rot exist. Fields are commonly infected through contaminated cuttings. Once in the field, the fungus penetrates healthy plants through open wounds. Yield losses may be up to 50 percent, and are more likely under warm weather and in dry soils. Plants normally die within a few days after visible symptoms appear in the plant. The vascular tissues of affected plants turn dark brown or black, especially close to the soil level. Leaves of susceptible plants may also turn yellow or brown. Resistant or tolerant cultivars grown in the continental U.S. include 'Jewel', 'Redgold', 'Nemagold', and 'Centennial'. In

addition to resistance, other controls include crop rotation to lower soil disease pressure, selection of seed roots from disease-free fields, and fungicide treatments.

Scurf

Symptoms caused by the asexual fungus *Monilochaetes infusans* include black blotches on stem tissue near the soil level and on the surface of fleshy roots. Infection also causes shrinkage during storage which results in unmarketable roots. Affected roots are conspicuous as they are cleaned for market. Infections in the field proceed faster in poorly drained soils. Animal manure applications and soils high in organic matter may increase the incidence of scurf. Recommended controls include root seed treatment before planting, treatment of the basal portion of the stem near the soil level, use of clean seed roots and cuttings, and a 3- to 4-year rotation.

Soil Rot

Symptoms on fleshy roots caused by the prokaryotic microorganism (not a fungus) *Streptomyces ipomoea* include malformed roots, surface pits and scabby cavities, as well as black spots on the crevices. The lesions are normally smaller than an inch in size. Affected plants appear stunted and may die before the end of the growing season. Controls include the use of resistant cultivars, sulfur applications to lower soil pH to 5.2, and soil fumigation. This organism persists by feeding on organic matter residue in the soil and does not require sweetpotato residues to survive. Rotations with other crops may reduce crop losses from soil rot in sweetpotato. Because dry soil conditions favor disease growth, even watering throughout the growing season is recommended.

Weeds

Proper cultivation, field selection, rotations, and timely applications can reduce the volume of herbicides applied for weed control in sweetpotato fields. Weeds may be controlled by the "flush" control technique. After the field is prepared for planting, including pre-plant fertilization, sprinkle irrigate the field to promote germination of weed seeds near the soil surface. The field is then treated with a preplant contact herbicide to kill the initial "flush" of growth. This may be repeated a second time. The sweetpotatoes may then be planted after either 15 or 30 days, depending on the number of "flush-growths" which were promoted to kill the germi-

nating weed population. Fields should be kept weed-free during the first 4 to 8 weeks of growth, after which the vines will completely cover the field. Weeds are also kept in check with the cultivation performed by disk hillers during the hilling operation. Herbicides may damage sweetpotatoes if applied incorrectly.

Some sweetpotato cultivars have been identified which show allelopathy toward plants of other species grown in proximity. For example, sweetpotato has been shown to reduce the growth of the yellow nutsedge weed and of sorghum. More research is needed to identify promising cultivars and to develop management techniques to maximize the sweetpotato's allelopathic efficiency against weeds.

HARVEST AND POSTHARVEST TREATMENTS

Maturity and Harvest

Sweetpotatoes are harvested as soon as the roots reach marketable size, which is 4 to 6 months after planting under Hawai'i conditions. Unmarketable "jumbos" may develop if plants are left in the field longer than desirable. Sweetpotato weevil outbreaks may also increase crop losses if plants are left in the field beyond its normal harvest time. A rotary or flail-type mower is used to mow the vines at the base. Vines are then either removed or rolled into adjacent rows before harvesting. The roots are spaded out by hand or plowed out with a middlebuster (double moldboard plow) or with a modified potato harvester (Figure 6). Roots fall to the ground at the end of the digger, where they are selected, placed in crates, and transported to the packing shed. In the



Figure 6. Modified tractor-pulled potato harvesters can be used for harvesting sweetpotato. The fields are first mowed and foliage removed before digging sweetpotato with this type of equipment.

packing shed, roots are washed. Oversized ones or those damaged by weevils, nematodes, diseases, or machinery are culled. Fleshy root damage should be minimized when harvesting in dry soils. If the harvest operation is conducted in wet soil, allow roots to dry naturally in a shaded area until the soil dries. Then remove the soil by gently rubbing with the hands.

Production Yields

Average yields in Hawai'i are about 12,000 lbs/A. This is below the average yields of over 20,000 lbs/A which are obtained in commercial operations on Moloka'i. Good yields range from 30 to 35,000 lbs/A. Yields will vary depending on growing season with higher yields obtained when planted between March and May and with lower yields when planted in the fall. Adequate yields are obtained when planting from February to July (Figure 4). Fertilizer applications should be modified depending on the expected yields for each planting season. Good yields in the continental U.S. are about 17,500 lbs/A with plant populations of 12,400/A.

Curing, Holding, and Storage

No "in-house" curing is practiced in Hawai'i. Roots are shipped soon after harvest. Curing treatments in production areas where this is practiced include storage at 85°F and 90 to 98 relative humidity (RH) for 4 to 7 days with ventilation, and then stored at 60°F with ventilation. Chilling damage occurs below 55°F. Curing results in the formation of a cork-like layer beneath the skin or in fleshy areas which have been bruised. Benefits of curing include increased sugar content and flavor, suberization of periderm tissue to protect the roots against bruises and disease attack, and improvement of shelf-life by reducing respiration and water loss. Roots lose about 3 to 6 percent of their weight during the curing process. Cured sweetpotato can be stored for 4 to 7 months. Roots are stored at 55 to 60°F and 85 to 90 RH. Sweetpotato roots will not store well if: (1) wet soil conditions are prevalent just prior to harvest, (2) the roots are chilled below 50°F for a period of over 5 days after harvest, or (3) the roots are not properly cured prior to storage.

Packing

Sweetpotatoes are packed in 50 lb crates or 40 lb cartons. Weight loss during transit and marketing is minimized if roots are held in perforated film bags (32 quarter-inch holes in a 3 to 5 lb polyethylene bag).

Grades

U.S. grading standards include:

1. U.S. No. 1 Extra: length – no less than 3 inches and no more than 9 inches; width – no less than 1.75 inches and no more than 3.5 inches; weight – 18 oz per root.
2. U.S. No. 1: length – no less than 3 inches and no greater than 3.5 inches and weight of 20 oz per root.
3. U.S. No. 2: length greater than 1.5 inches and root weight of 36 oz.
4. Culls.

Consult the Hawai'i Department of Agriculture Marketing and Consumer Services Division for an update on current local grading marketing standards for sweetpotatoes: Hawai'i Fancy (Grade AA), Hawai'i No. 1 (Grade A), and Hawai'i No. 2 (Grade B).

Market Information

Sweetpotato is planted and harvested weekly in Hawai'i. About 1.3 million pounds of sweetpotato are grown annually, and local demand for sweetpotato has been steady over the past decade. About 40 percent of the sweetpotato consumed in Hawai'i is imported from the continental U.S. (Figure 7). Before planting sweetpotato, prospective growers need to target a market, understand monthly market trends, and identify specific buyers. Production costs for sweetpotatoes in 1990 ranged from \$0.35 to 0.45 per pound. Prices normally dip from August to March. Returns from late spring to fall when yields are the highest are therefore the most positive (Figure 8). Nationally, harvest volumes are greatest from September to January, and lowest in June and July. North Carolina, Louisiana, and California

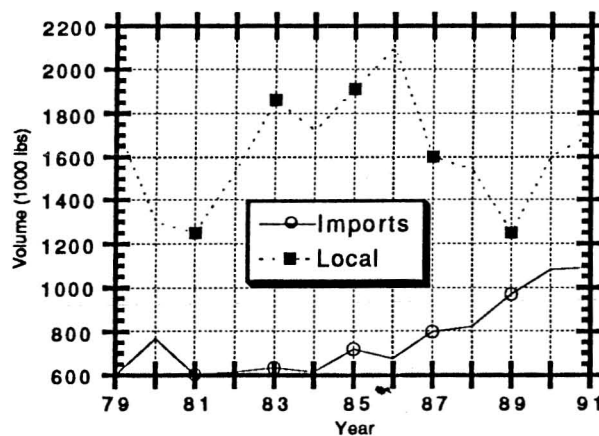


Figure 7. Hawai'i annual sweetpotato imports and local production from 1978 to 1991.

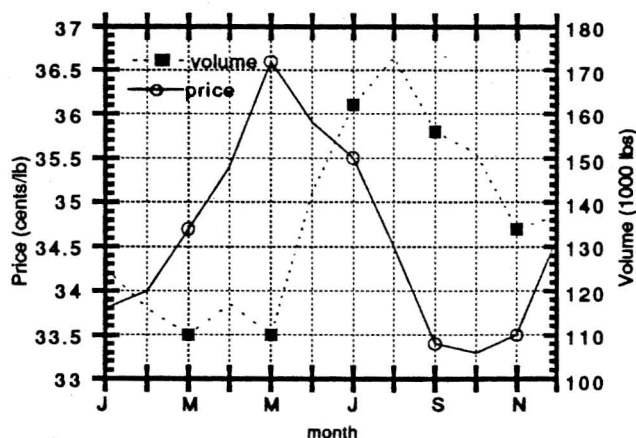


Figure 8. Average monthly price and volume for sweetpotato in Hawai'i 1986 to 1991.

are the largest sweetpotato producing states in the U.S. Per capita consumption of sweetpotatoes in the U.S. is about 4.5 lbs annually, but consumption may be higher with some ethnic groups in Hawai'i. The potential exists for developing processed products for export to the continental U.S. or Japan, where sweetpotato is increasingly being recognized as a healthy substitute for high-fat or high-calorie desserts or fast food snacks. Presently, fresh roots can not be exported to the continental U.S. primarily because there is a quarantine on the sweetpotato weevil and on wireworms. Sweetpotato shoots are normally marketed in low volumes in community farmers' markets or in the Honolulu Chinatown produce market.

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